

ST Elevation and Inverted T Wave as Another Normal Variant Mimicking Acute Myocardial Infarction: The Prevalence, Age, Gender, and Racial Distribution

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Background: Early repolarization (ERP) as a normal variant is a well-recognized ECG entity. There is another normal variant of ST elevation (STTNV) in the midprecordial leads, which is distinctively different from ERP in that the T waves are inverted in these leads while they are upright and tall in ERP. These findings can be easily mistaken for acute myocardial infarction or pericarditis. The purpose of this study is to publicize this entity and to determine its prevalence, age, gender, and racial distributions.

Methods: All ECGs taken in adults at a Minneapolis hospital in 2007 were reviewed and individuals with the following ECG findings were identified: 1–3 mm ST elevation ending in an inverted T wave in midprecordial leads with preserved R waves.

Results: A total of 11,424 patients (5997 men, 5427 women) had one or more ECGs in 2007. STTNV was seen in 101 patients, 97 (96%) of whom were black. Seventy-seven of 2084 (3.7%) black men and 20 of 2020 (1%) black women had STTNV. It was rare in other races (0 to 0.7%), particularly in white patients (1 of 5099 patients). It seems to be evenly distributed throughout the age. The ECG findings normalized in all 6 patients who underwent a treadmill stress test.

Conclusions: This entity is seen almost exclusively in blacks (3.7% of men, 1% of women), and is more or less evenly distributed throughout the age. Whether this variant is more often associated with malignant ventricular arrhythmias remains to be determined.

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early repolarization; ST elevation; ECG

ST elevation in the midprecordial leads as a normal variant, known as early repolarization (ERP), is a well-recognized electrocardiographic entity (Fig. 1A).¹ There is another normal variant of ST elevation, designated as STTNV in this article, that is distinctively different from ERP in that the T waves are inverted in these leads while they are upright and tall in ERP (Fig. 1B).² This normal variant can be easily mistaken for acute myocardial infarction or pericarditis.³

In contrast to ERP, STTNV is not a well-recognized entity and is still a source of considerable confusion among cardiologists, emergency

physicians, and general practitioners. The purpose of this study is to publicize this entity and to determine its prevalence, age, gender, and racial distributions.

METHODS

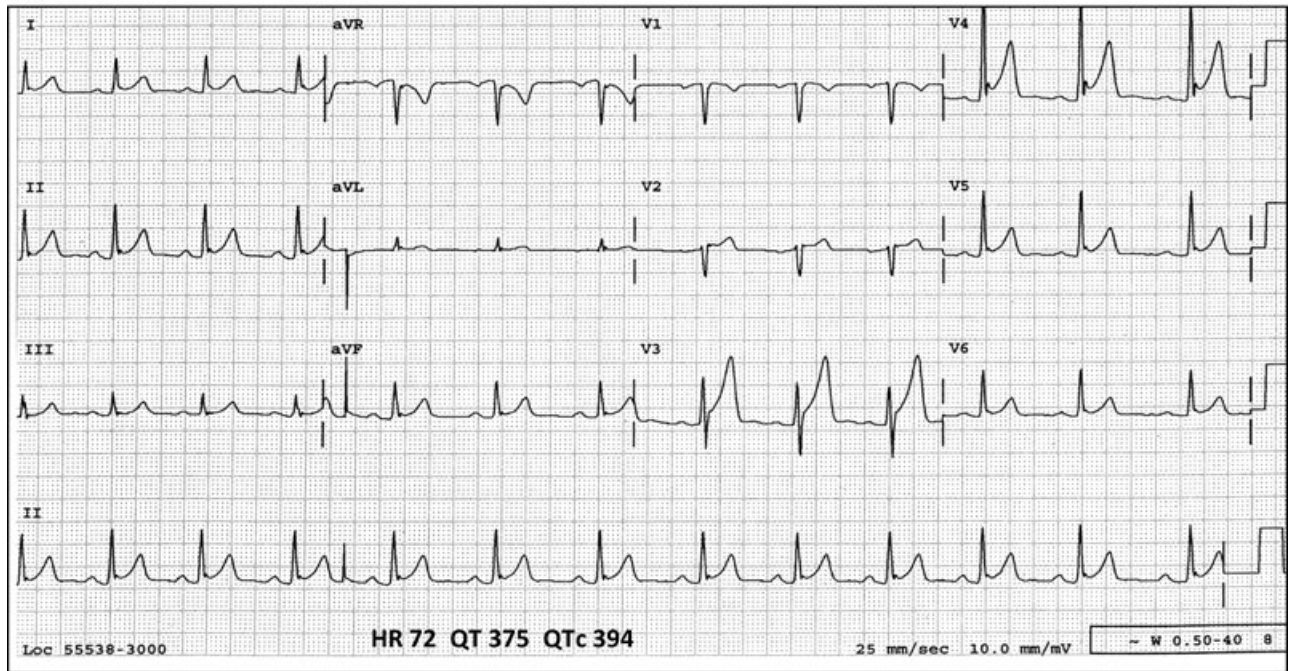
All the electrocardiograms (ECGs) taken in adult patients at the Hennepin County Medical Center in Minneapolis, MN during the year of 2007 were personally reviewed. All individuals with the following ECG findings were identified: 1–3 mm ST segment elevation ending in an inverted T wave in the midprecordial leads along with preserved

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A.



B.

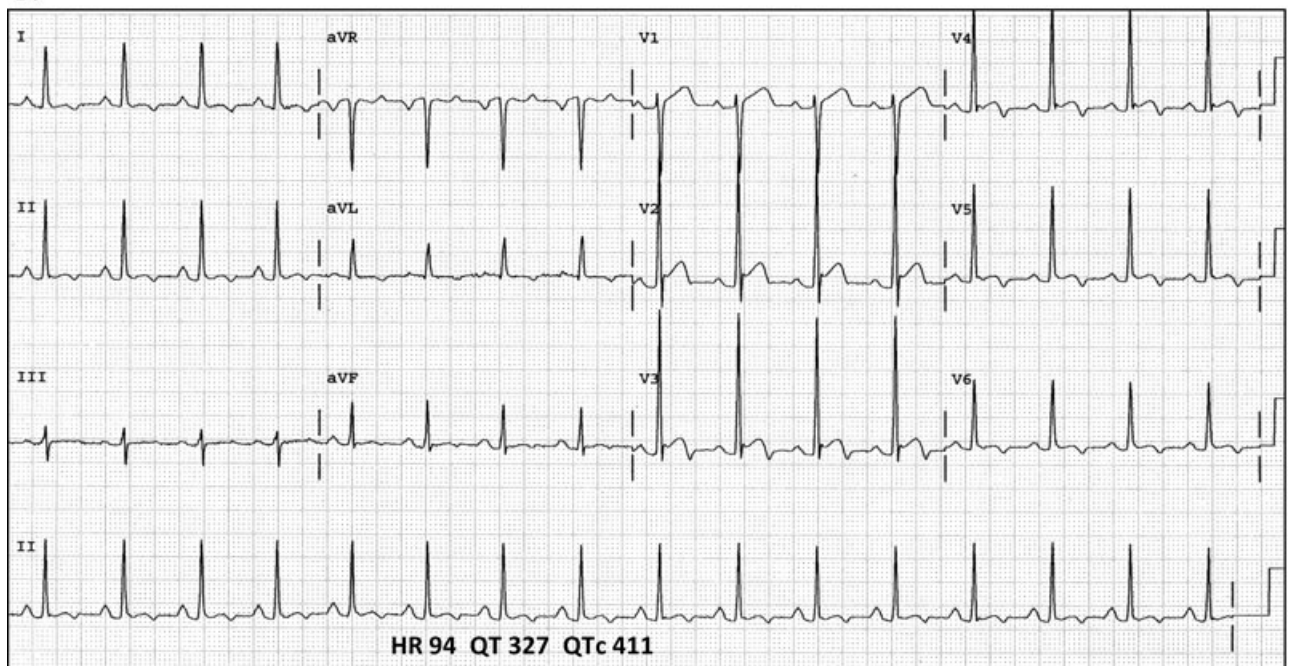


Figure 1. (A) Early Repolarization. ST segments are elevated in V₃ to V₆ and are concave. There is a notching at the J point in V₄. T waves are upright and tall. (B) ST-T changes of STTNV. ST segments are elevated in V₂ to V₆ and are concave. There is a notching at the J point in V₃ and V₄. T waves are inverted.

R waves (Fig. 1B). An acute myocardial infarction would be associated with a Q or QS wave in these leads by the time the T waves are inverted. The age,

race, and gender of all the patients were identified from the ECG database and the electronic medical record.

Table 1. Prevalence of STTNV According to Race and Gender

| | # Patients | # With Entity | Prevalence (%) |
|-------------------------------|------------|---------------|----------------|
| Black men | 2084 | 77 | 3.7 |
| Black women | 2020 | 20 | 1.0 |
| White men | 2822 | 1 | 0.04 |
| White women | 2277 | 0 | 0 |
| Latinos | 471 | 1 | 0.2 |
| Latinas | 411 | 1 | 0.2 |
| Asian men | 143 | 1 | 0.7 |
| Asian women | 168 | 0 | 0 |
| Native American men and women | 447 | 0 | 0 |

RESULTS

We screened 11,424 adult patients who had one or more ECGs in 2007. There were 5997 men (52.5%) and 5427 women (47.5%). STTNV was seen in 101 patients (0.9%), 97 (96%) of whom were black. This entity was seen in 3.7% (77/2084 patients) of black men and 1% (20/2020 patients) of black women, and rarely in other races (0–0.7%), particularly in whites (1 of 2822 white men and none of 2277 white women). (Table 1)

The prevalence was high (8.8%) in the 17–19 age range group for black men (Fig. 2) but the sample size is small (9 out of 102 black men). Otherwise,

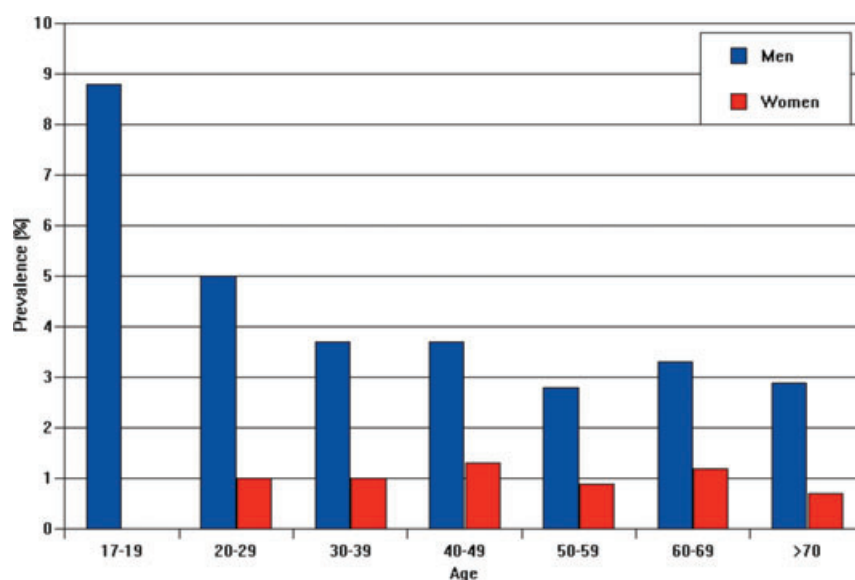
the prevalence of this entity is more or less evenly distributed throughout the age.

The ECG findings normalized in all six patients who underwent treadmill stress tests during the recovery phase (Fig. 3).

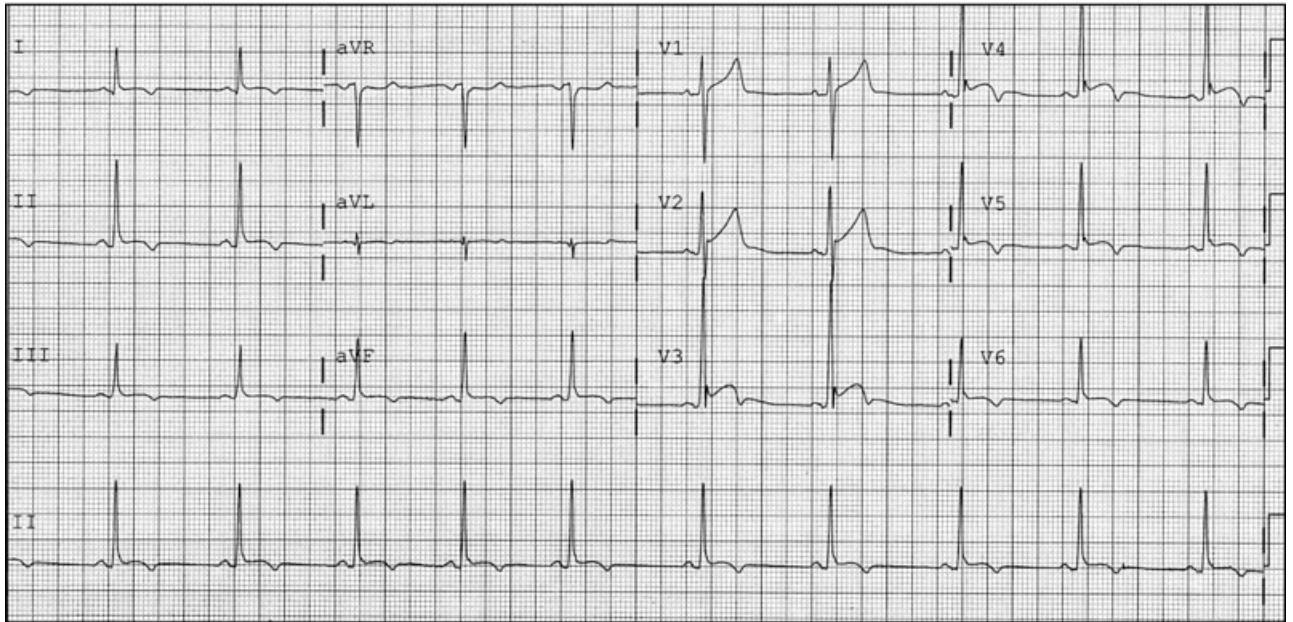
DISCUSSION

STTNV is seen almost exclusively in black patients (3.7% of black men and 1% of black women) and rarely in other races (0–0.7%). It is more or less evenly distributed throughout the age except in the 17–19 age group, where the prevalence is high at 8.8%, but the sample size of this group is small (102 men) and it needs to be verified in a larger study.

This study is not a population-based study. Rather, the ECGs are taken in adult patients at a county hospital as inpatients, outpatients, or in the emergency room for various reasons. The prevalence may be different in the general population. It is noteworthy that, while ERP is seen in 1% to 5% of the general population, it has been reported in 13% to 48% of patients presenting to the emergency rooms and coronary care units.^{4,5} If the increased prevalence of STTNV in the 17–19 years age group in this study is duplicated in a larger study, it could mean that, like ERP, many lose the STTNV as they become 20 or 30 years old. It would be interesting to find out the prevalence of this entity in the pediatric population.

**Figure 2.** Prevalence of STTNV in black patients according to age.

A.



B.

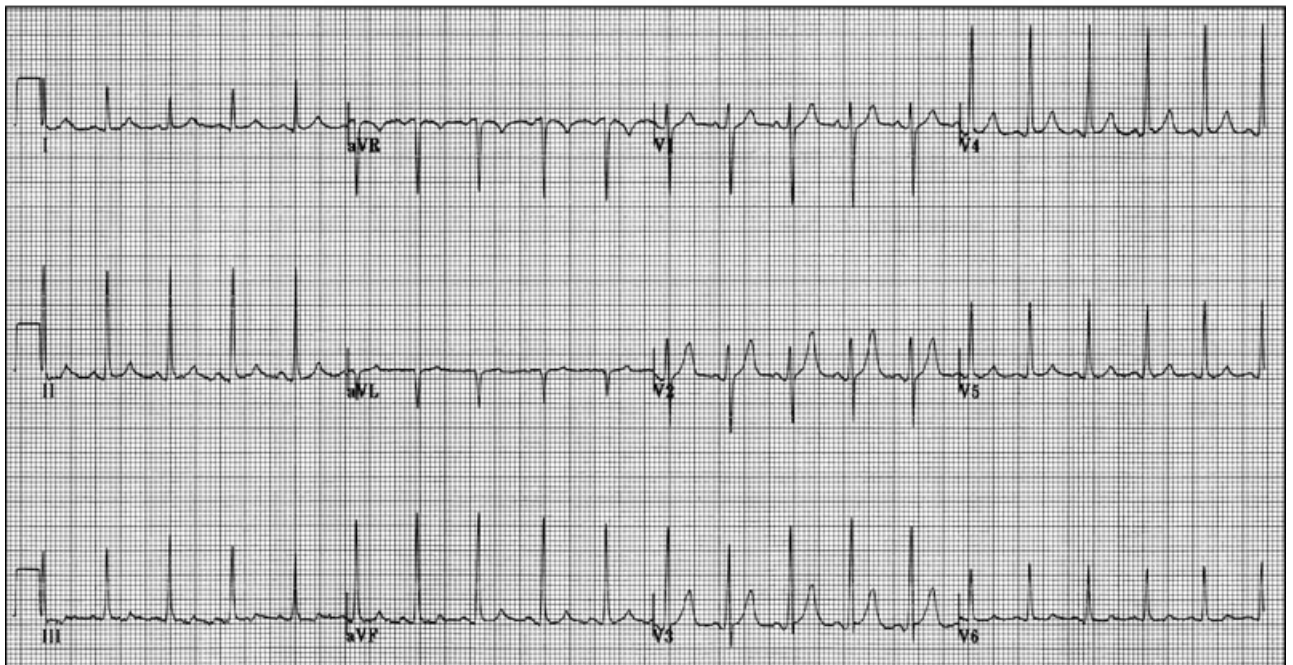


Figure 3. (A) Resting ECG of patient with STTNV. (B) Normalization of the ST-T changes with treadmill exercise test.

The ECG pattern described here (ST elevation in the midprecordial leads with inverted T waves and preserved R waves, designated as STTNV in this article) as a normal variant has been recog-

nized since the 1950s, but unlike ERP, it is not well known among the physicians.^{2,6} If one is not aware of the presence of this entity, the ECG will always raise the suspicion of acute myocardial

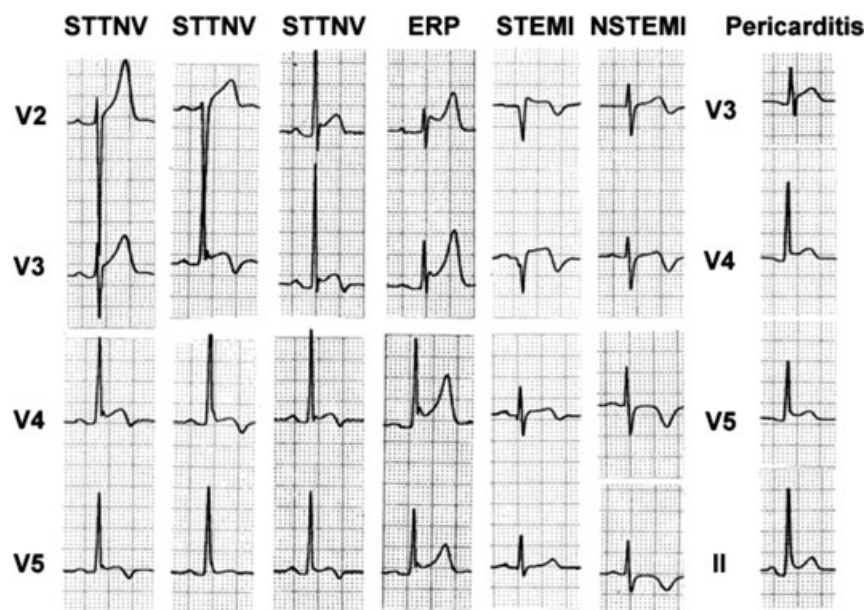


Figure 4. Comparison of various types of ST elevation in the midprecordial leads. STTNV: ST elevation ending in an inverted T wave as a normal variant. ST segments are elevated in the midprecordial leads. The ST segment tends to be coved. T waves are inverted. There is notching at the J point. ERP: Early repolarization as a normal variant. T waves are upright and tall. The ST segment is concave. There is a notching at the J point. STEMI: Acute anteroseptal ST-elevation myocardial infarction. ST segments are elevated and T waves are inverted but R waves are replaced by a Q or QS wave. NSTEMI: Acute non-ST-elevation myocardial infarction. ST segment are not elevated. Inverted T waves are broad based. PERICARDITIS: Acute pericarditis. ST segments are diffusely elevated including in lead II. PR segment depression is more distinct in lead II. T waves are not inverted.

infarction or acute pericarditis, making one to resort to echocardiography or coronary angiography unnecessarily. The first step to the right direction is to know that this entity exists.

There are characteristic ECG features that differentiate STTNV from other ST segments elevation categories (Fig. 4). As in ERP, there is a notch at the junction of QRS and ST (the J point). In addition, there is often an early QRS transition in the anterior chest leads with a tall R wave in V₂ and V₃. Sometimes, inferior leads are also involved but to a lesser degree of ST elevation and T-wave inversion. In ST-elevation myocardial infarction, Q or QS waves are commonly present by the time T-wave inversion takes place. In non-ST-elevation myocardial infarction, the ST segments are not elevated and the inverted T waves are wider than in STTNV. In pericarditis, the ST elevation is more diffused, the PR segment depression is more distinct, and T waves are usually not inverted when

the ST segments are elevated.^{3,7} They may become inverted when the ST segment normalizes.

Exercise tends to normalize the ST segment elevation in ERP. This phenomenon has been suggested as a diagnostic tool to evaluate patients with ERP.⁸ In a report of 25 persons with ERP, the STTNV normalized with exercise stress test in all of them.⁶ We also observed transient normalization of the ST-T changes near the peak of exercise or during early recovery in all 6 patients who underwent the stress test.

Until lately, ERP has been considered completely benign. Recent reports suggest that it might be associated with vulnerability to idiopathic ventricular fibrillation.^{9–11} While ERP is present in 1–5% of the general population, 31% of patients resuscitated from idiopathic ventricular fibrillation had ERP.⁹ Left precordial terminal QRS notching (J wave) was more prevalent in ERP associated with idiopathic ventricular tachycardia or fibrillation compared to

patients with ERP and a benign course.¹² Moreover, Tikkanen et al. showed that a J wave in the inferior leads was more often associated with death from arrhythmia, but not when present only in the lateral leads.¹¹ Whether the STTNV is more often associated with ventricular arrhythmias remains to be determined.

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